Remarks:

Applicant thanks the Examiner for his courtesies during an interview on Wednesday, January 26, 2005. During this interview the patentability of new claim 75 over the Cummins and White references was discussed. In particular, the issue of whether Cummins or White disclose, teach, or suggest the use of a memoryless nonlinear audio amplifier that provides "memoryless gain compression directly on a sound signal that is (1) received from the first bandpass filter and (2) exhibits instantaneous amplitudes greater than a compression threshold" was discussed. As a result of this interview, it is Applicant's understanding that the Examiner is in agreement that the Cummins and White references fail to disclose, teach, or suggest such a feature. Applicant more fully sets forth this issue in specific remarks below, but as a preliminary matter, Applicant submits Exhibits 2 and 3, which are excerpts from recognized textbooks in the art. Exhibits 2 and 3 confirm that the ordinary and reasonable meaning of the word "memoryless" in the art comports with Applicant's position on the claims.

Claims 2-19, 21-32, and 34-74 were pending in this application at the time of the November 2, 2004 Office Action. That Office Action allowed claims 59 and 66. That Office Action further identified claims 4, 5, 17-19, 22-27, 36, 37, 40, 42, 44, and 52-54 as being allowable if rewritten in independent form including all of the limitations of the base claim and any intervening claims. By this amendment, claims 4, 5, 17, 22, 36, 37, 40, 42, 44, and 52 have been amended into independent form by including all of the limitations of their respective base claims and intervening claims (where applicable). As such, Applicant respectfully submits that claims 4, 5, 17, 22, 36, 37, 40, 42, 44, and 52 are now in condition for allowance. Further, Applicant has amended claims 6-8, 28, 30, 34, 38, 39, 41, 45, 49, and 51 to depend from claims previously identified as allowable. Lastly, claims 2, 3, 21, 31, 32, 35, 55-58, and 60-65 and 67-74 have been canceled without prejudice. Applicant reserves the right to later pursue the subject matter of these canceled claims via one or more continuation or continuation-in-part patent applications.

By this amendment, Applicant has also added new claims 75-98. Support for the limitations of these claims can be found throughout the originally-filed patent application. For example, support for new claims 75 and 76 can be found with reference to Figure 1 (and the corresponding text in the application). Support for new claim 77 can be found at p. 19, line 30 – p. 20, line 4. Support for new claim 78 can be found at p. 22, lines 8-16. Support for new claim 79 can be found in Figure 10 and at p. 34, line 1 – p. 35, line 2. Support for new claim 80 can be found in Figure 2. Support for new claim 81 and 82 can be found in Figures 14-15 and at p. 19, lines 14-29. Support for new claims 83 and 85 can be found at p. 20, lines 8-25 and p. 47, line 17 – p. 48, line 2. Support for new claims 84 and 91 can be found in Figure 21. Support for new claim 86 can be found in Figures 14-15 and at p. 34, lines 1-18. Support for new claims 87-90 can be found in Figures 22-23 and at p. 44, line 10 – p. 46, line 11. Support for new claim 92 can be found at p. 13, lines 1-3. Support for new claim 93 can be found at p. 42, lines 24-25. Support for new claims 94-96 can be found at p. 51, line 18 – p. 52, line 2. Lastly, support for new claims 97 and 98 can be found at p. 13, lines 8-9.

Applicant will now explain the patentability of new claims 75-98 over the cited references (Cummins and White).

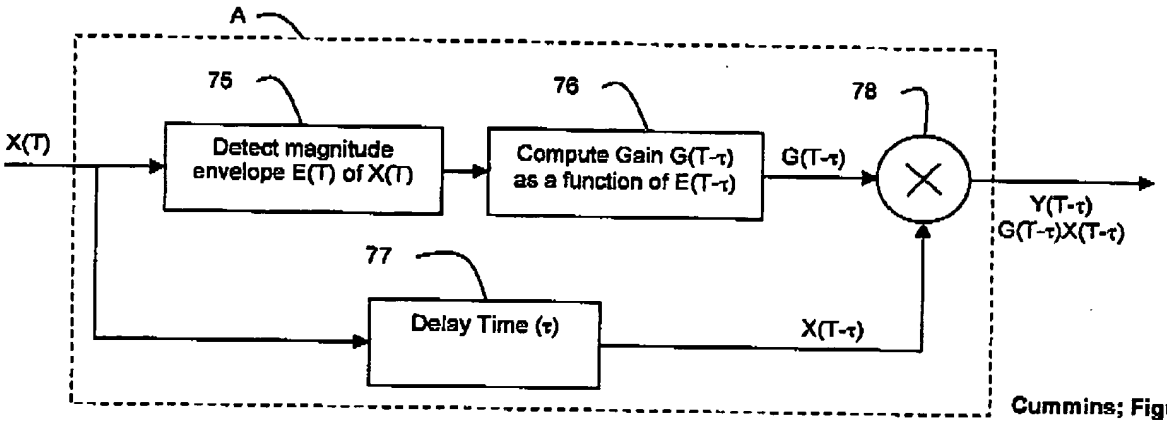
New claim 75 recites that the hearing aid device includes a "memoryless nonlinear compressive audio amplifier" that provides "memoryless gain compression directly on a sound signal" received from a bandpass filter that "exhibits instantaneous sound amplitudes greater than a compression threshold". The Cummins reference and the White reference, when considered separately or in combination, fail to teach the use of such a "memoryless nonlinear compressive audio amplifier" to one of ordinary skill in the art. As such, Applicant respectfully submits that new claim 75 is nonobvious with respect to the combination of Cummins and White.

The fundamental difference between Applicant's new claim 75 and the combined teachings of the Cummins and White references is that new claim 75 defines an invention that eliminates the prior art's requirement for a short-term computation on the audio input signal to provide a control signal for implementing ***a desired gain compression***. New claim 75

recites the use of a bandpass nonlinearity (BPNL) amplifier with a memoryless nonlinear compressive audio amplifier that directly provides the desired audio gain compression. This gain compression is provided whether or not the compression threshold is adjusted from its quiescent state. Furthermore, to independently provide a desired nonlinear waveform quality, Applicant claims the use of a controller to adjust the memoryless nonlinear compressive audio amplifier's compression threshold (preferably via a short-term computation on the audio input signal to provide a control signal for appropriately adjusting the compression threshold). The immediate consequences are (1) gain compression providing protection against overamplification of sound is assured independently of the control mechanism, (2) no short term computations are necessary with the invention of new claim 75 to provide gain compression because the gain compression is built into the memoryless amplifier, and (3) the control mechanism for the compression threshold can be set to provide useful nonlinear waveform compression that enhances relatively weak speech sounds. These ideas are summarized in figure 1 of the Applicant's specification.

Both Cummins and White modulate the gains of *linear* amplifiers with nonlinear functions of the *envelopes* of the audio input or subbands thereof. The bandwidths of the modulation functions are chosen to avoid audible distortion. Compromises are necessary, because greater distortion results from the wider bandwidths that correspond to rapid attack times that avoid overamplification of rapidly increasing sound levels. The following analysis of the teachings present in Cummins and White demonstrates their common strategy for nonlinear gain control and further illustrates how this common strategy is wholly different from the invention of new claim 75.

Figure 4 of the Cummins reference is reproduced below, although Applicant has added dashed box A to help illustrate the differences between new claim 75 and the Cummins reference.[1]



Cummins; Figure 4

In this figure, X(T) represents an incoming sample of a sound signal. (See Cummins, col. 7, lines 43-48). Box 75 serves an envelope detector that calculates an envelope E(T) for the sound signal based on X(T) and a plurality of previous samples. (See Cummins, col. 7, lines 50-51). Therefore, it is clear that E(T) is not a memoryless function of sound signal X because previously stored samples for X must be used to compute E(T). For example, assuming a sampling rate of 14,000 samples per second as per Cummins' teaching at col. 6, lines 41-44, and further assuming a time constant of 1-2 ms as per Cummins' teaching at col. 3, line 27, the number of samples that would be included in the RMS envelope calculation of E(T) would be around 14 to 28 samples.

[1] Applicant disagrees with the Office Action's statement at page 2 of the 11/2/04 Office Action that Cummins uses "an amplifier not relying on previous inputs" (see also page 2 of the previous Final Office Action). As explained in detail in this response, the Cummins amplifier at issue (the amplifier A shown above – and more specifically the combination of blocks 75, 76 and 78) does in fact rely upon previous inputs to compute the appropriate gain for the received sound signal because the envelope calculations disclosed by Cummins at block 75 operate on a plurality (1-2 milliseconds worth) of input samples.

Because of the delays inherent in this envelope calculation, a time delay period τ is provided by block 77 to synch the incoming sound samples with the appropriate gain value G computed by box 76. (See Cummins, col. 7, lines 55-64).

Once E(T) has been computed, box 76 computes a gain $G(T-\tau)$ as a function of $E(T-\tau)$, thus gain G can be expressed as $G(T-\tau)=G(E(T-\tau))$. After G has been computed, input sample $X(T-\tau)$ is multiplied by $G(E(t-\tau))$ at multiplication block 78. Therefore, the input/output relationship provided by amplifier A can be expressed as $Y(T-\tau)=G(E(T-\tau))X(T-\tau)$, wherein $Y(T-\tau)$ is the amplifier output representing the amplified sound signal. While gain G can be said to operate memorylessly on the envelope E, gain block 76 does not operate directly on the sound signal as required by new claim 75 – ***instead it operates on an envelope of the sound signal while the sound signal passes through block 77 in the branch below***. It is only block 78 that operates directly on the sound signal (or in the abstract, block A that operates directly on the sound signal). However, block 78 (as well as *the amplifier A) fails to provide "**memoryless** gain compression **directly** on a sound signal" received from a bandpass filter that "exhibits instantaneous sound amplitudes greater than a compression threshold" **because E is not a memoryless function of X, which therefore dictates that Y is not a memoryless function of X.*** Thus Cummins requires short-term computations based on previous samples of the audio input signal to provide a control signal for implementing a desired gain compression.

This requirement by the Cummins amplifier is further apparent from a review of Figures 9-11 of the Cummins patent. Figure 9 discloses the high level routines performed by the microprocessor that implements amplifier A. "Main Program" block 91 is detailed in Figure 10 and "Interrupt Routine" block 92 is illustrated in Figure 11. The Main Program uses the envelope E calculated by the Interrupt Routine to calculate G. (See Cummins, col. 10, lines 38-43). However, the Interrupt Routine only provides a new value for E to the Main Program in one millisecond intervals:

> After completion of the check of the mode switches and the resetting of parameters [by the Main Program], ***the [main] program then waits until the millisecond counter is less than or equal to zero (block 101). This counter is***

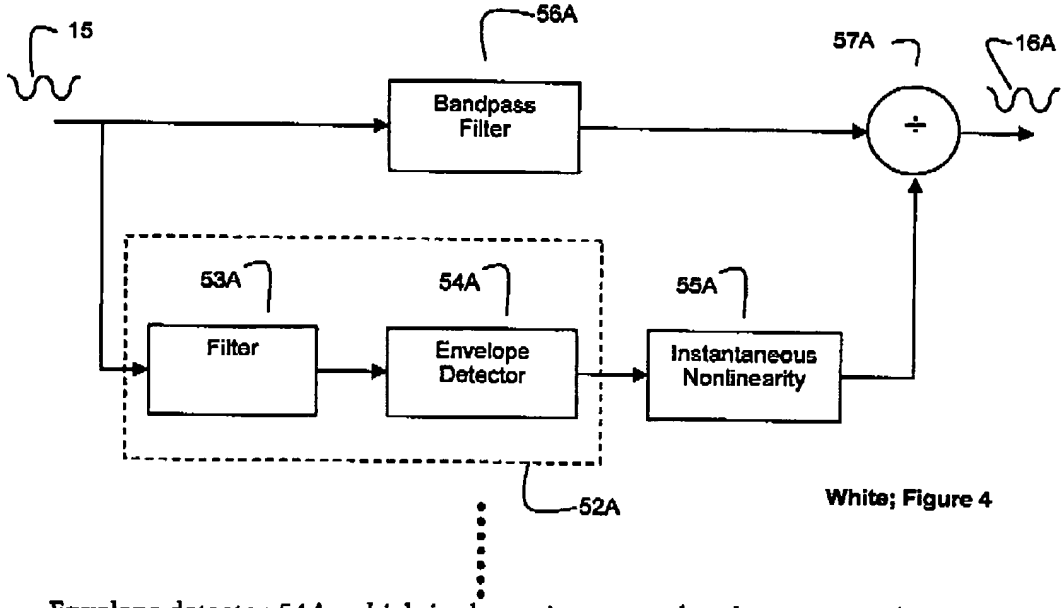
> ***decremented in the interrupt routine. After the counter reaches zero or less than zero, the millisecond counter is reset (block 102) to a positive number. The number governs how often the main program is executed.*** For example, if it is desired to execute the main program ***about once every millisecond***, the millisecond counter is set to a number (e.g., 15) which accomplishes that result. (See Cummins; col. 12, lines 40-50 (emphasis added)).

Therefore, it is clear that the Main Program will receive a new value for E only on millisecond intervals. By derivation, G will change on only millisecond intervals as a result of an envelope computation based on a plurality of previous sound samples. Contrarily, and as stated above, the invention of new claim 75 provides ***"memoryless*** gain compression ***directly on a sound signal"*** received from a bandpass filter that "exhibits ***instantaneous amplitudes greater than a compression threshold"***.

The White patent fails to bridge the gap between the Cummins reference and new claim 75. White discloses an amplifier that is essentially a multichannel implementation of the Cummins amplifier. Subtle differences between the White amplifier and the Cummins amplifier are that (1) whereas the gain G in Cummins is provided as G(E(t)), the gain G in White is provided as 1/G(E(t)), and (2) the envelope calculated in the White amplifier is for a broader band signal than the particular audio subband being controlled in the channel. However, neither of these distinctions relate to the limitations of new claim 75. White essentially uses the same strategy for gain compression as Cummins – it discloses conventional slowly varying gain control based upon a short-term calculation using a plurality of previous samples.

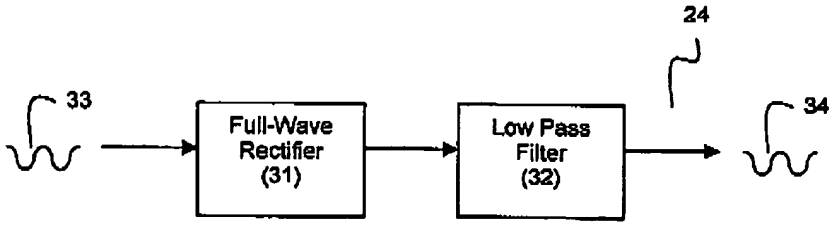
Figure 4 of the White patent illustrates the multichannel implementation of this amplifier. A single channel of Figure 4 is reproduced below, which details the compressor 45 (shown as a block in Figure 2) as being comprised of an integration filter 53A, an envelope detector 54A, an instantaneous nonlinearity block 55A, and a divider block 57A. This configuration receives sound signal 15, computes a gain with the compressor components (53A, 54A, 55A and 57A), passes the sound signal 15 through a bandpass filter 56A, and divides the bandpass-filtered sound signal by the gain computed by block 55A to produce

amplified output 16A. The block labeled 52A serves to measure the intensity of an audio signal, which serves an input to the instantaneous nonlinearity 55A. The intensity measurement performed by 52A is a short-term calculation, as detailed below.



White; Figure 4

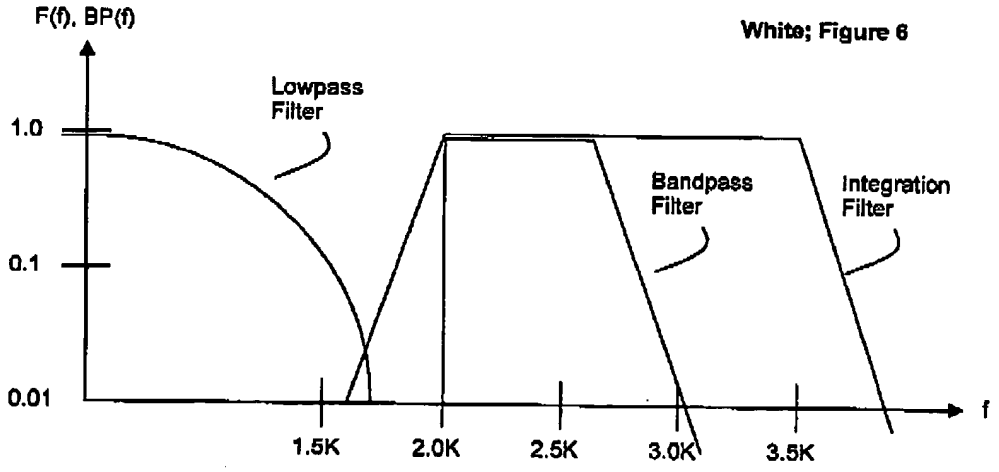
Envelope detector 54A, which is shown in greater detail in Figure 7 (reproduced below), comprises a full wave rectifier 31 followed by a lowpass filter 32. The White patent uses both reference number 24 and 54 to describe the same envelope detector. (See White, col. 8, lines 6-7). With reference to Figure 4, it can be seen that rectifier 31 receives the output signal 33 from the integration filter and provides a rectified version of signal 33 to low pass filter 32 to produce a low pass filter output 34. Instantaneous nonlinearity block 55A then operates on the output 34 from the low pass filter 32.



White; Figure 7

The filter characteristics for bandpass filter 56A, integration filter 53A and envelope detector 54A are shown in Figure 6 of the White patent, which is reproduced below. White teaches:

> The selection of a proper integration band (i.e., a proper integration filter 53) for each channel is basically an empirical task. Nevertheless several general points can be made. First, the integration filter 53 ***should generally be weighted so as to include only a portion of the input signal that is lower in frequency than the lowest frequency passed by the bandpass filter 56 of the channel***. FIG. 6 illustrates the relationships between the three filters in a typical channel. While it is desirable for the intensity detector 52 to be able to respond quickly to changes in level, ***to minimize spectral distortion the lowpass filter 32 (see FIG. 7) of the envelope detector should only pass spectral components which represent the envelope of the signal passed by the integration filter 53***. Therefore the upper limit for the lowpass filter 32's bandpass should be set no higher than the low frequency edge of the non-envelope components of the signal passed by integration filter 53 and the full-wave rectifier 31. (See White, col. 8, lines 47-65 (emphasis added)).



It is clear therefore from Figure 6 and from White's express teachings, that the instantaneous nonlinearity of White's amplification technique ***does not operate directly on the sound signal***. The sound signal in the White amplifier resides in the passband defined by the bandpass filter 56A (between 2 kHz and 3 kHz) in Figure 6. The instantaneous nonlinearity

block 55A, however, operates only on an envelope signal that is passed by integration filter 53A and low pass filter 32. As can be seen in Figure 6, this signal is entirely outside the frequency range of the sound signal output from the bandpass filter 56A.

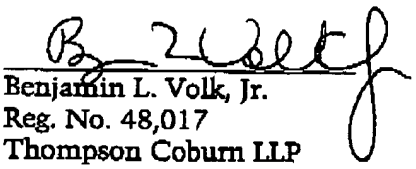
Therefore, as with the Cummins amplifier, the White amplifier fails to disclose, teach, or suggest a "memoryless nonlinear compressive audio amplifier" that is "configured to provide ***memoryless*** gain compression ***directly on a sound signal*** that is (1) ***received from the first bandpass filter*** and (2) exhibits instantaneous amplitudes greater than a compression threshold" as required by new claim 75. The instantaneous nonlinearity block 55A of White operates ***on the envelope of a sound signal rather than directly on the sound signal***. The desired sound signal in White instead directly passes through bandpass filter 56A and divider 57A. However, because the gain provided by divider 57A is not a memoryless function of the input sound signal 15 (due to the requirement for envelope detectors to process some duration of the sound signal to compute the envelope), the White amplification technique fails to render new claim 75 obvious, whether White is considered alone or in combination with the Cummins patent. In fact, White expressly teaches away from the limitations of new claim 75 because it teaches that fast-acting gain changes in response to sound signal changes should be avoided to prevent spectral distortion. (See White, col. 8, lines 55-65). Proceeding contrary to this conventional wisdom, Applicant has invented a hearing aid device wherein memoryless gain compression is provided with independent control of waveform quality.

Conclusion:

In view of the foregoing, Applicant respectfully submits that new claim 75 is not rendered obvious by the combination of the White patent with the Cummins reference. Furthermore, as new claims 76-98 are dependent from new claim 75, Applicant respectfully submits that new claims 76-98 are nonobvious for the same reasons expressed in connection with new claim 75. Furthermore, Applicant respectfully submits that the combination of claim 75 with the limitations recited in new claim 76-98 are also not disclosed, taught or suggested

by the combination of the Cummins patent with the White patent. As such, favorable action is respectfully requested.

Respectfully submitted,



Benjamin L. Volk, Jr.
Reg. No. 48,017
Thompson Coburn LLP
One US Bank Plaza
St. Louis, Missouri 63101
(314) 552-6000
(314) 552-7000 (fax)